

IN THE CLAIMS:

1-9. (cancelled)

10. (currently amended) The process of Claim [[4]] 17, wherein the process action of representing each entity by a coordinate frame and an extent, comprises a process action of characterizing an entity's extent as a point coincident with the origin of the entity's coordinate frame whenever an external source fails to provide information defining a size for the entity's extent.

11-16. (cancelled)

17. (currently amended) The process of Claim 14, A computer-implemented process for providing a geometric model database for use in a ubiquitous computing environment to respond to queries about the environment's geometric state, comprising using a computer to perform the following process actions:

accepting information about the geometric state of the environment;

building a geometric model database of the environment based on an initial input of said information, comprising,

establishing a set of entities that are of interest in the environment, each entity of which is represented by at least a coordinate frame unique to that entity and an extent, wherein said extent defines one of (i) the physical size of the entity, or (ii) the service region of the entity,

characterizing the location of each entity in the environment in terms of the coordinate frame of at least one other entity, rather than in terms of a coordinate frame common to all entities, using a measurement defining the entity's relationship to at least one of said other entities, wherein said measurement comprises the position and orientation of each other entity's coordinate frame origin in terms of the coordinate frame of the entity under

consideration and a spatial uncertainty estimate which is indicative of the accuracy of the method used to obtain the measurement, and wherein each measurement is provided to the geometric model database by an external source, and wherein more than one measurement defining an entity's relationship to another entity may be provided by separate external sources, and wherein the process action of characterizing the location of each entity in the environment relative to other entities using a measurement, further comprises an action of, whenever more than one measurement defining an entity's relationship to another entity is received, combining said measurements using their relative uncertainties as weights;

maintaining the geometric model database by modifying it based on the input of updated information about the geometric state of the environment; and

responding to queries concerning the geometric relationships between entities in the environment using the geometric model database.

18. (currently amended) The process of Claim 4, A computer-implemented process for providing a geometric model database for use in a ubiquitous computing environment to respond to queries about the environment's geometric state, comprising using a computer to perform the following process actions:

accepting information about the geometric state of the environment;

building a geometric model database of the environment based on an initial input of said information, comprising,

establishing a set of entities that are of interest in the environment, each entity of which is represented by at least a coordinate frame unique to that entity and an extent, wherein said extent defines one of (i) the physical size of the entity; or (ii) the service region of the entity,

characterizing the location of each entity in the environment in terms of the coordinate frame of at least one other entity, rather than in terms

of a coordinate frame common to all entities, using a measurement defining the entity's relationship to at least one of said other entities wherein the process action of characterizing the location of each entity in the environment in terms of the coordinate frame of at least one other entity using a measurement defining the entity's relationship to at least one of said other entities, comprises said characterizing comprising an action of revising the measurements, said revising action comprising the actions of:

inputting a spatial uncertainty estimate associated with each measurement which is indicative of the accuracy of the method used to obtain the measurement;

identifying cycles of measurements among the measurements, wherein a cycle of measurements is defined as a string of measurements starting at the origin of a first entity frame in the cycle and following measurements from one entity to the next until reaching a last measurement in the cycle representing the relationship between the coordinate frame of a next to last entity of the cycle and the origin of said first entity frame; and

for each cycle identified, computing the difference between a given location of said first entity frame's origin and the location of that origin as indicated by following the chain of measurements making up the cycle; and

computing revised measurements for the identified cycles by simultaneously adjusting the measurements based on their associated uncertainty estimates so as to make the given location of said first entity frame's origin in each of the identified cycles match the location of that origin as indicated by following the chain of measurements making up the cycle;

maintaining the geometric model database by modifying it based on the input of updated information about the geometric state of the environment; and

responding to queries concerning the geometric relationships between entities in the environment using the geometric model database.

19. (original) The process of Claim 18, further comprising a process action of repeating the process actions of inputting spatial uncertainty estimates, identifying cycles of measurements, computing the difference between a given location of said first entity frame's origin and the location of that origin as indicated by following the chain of measurements making up the cycle for each cycle identified, and computing revised measurements, whenever new measurements are provided.

20. (original) The process of Claim 18, further comprising a process action of repeating the process actions of inputting spatial uncertainty estimates, identifying cycles of measurements, computing the difference between a given location of said first entity frame's origin and the location of that origin as indicated by following the chain of measurements making up the cycle for each cycle identified, and computing revised measurements, on a periodic basis.

21. (currently amended) The process of Claim 4, A computer-implemented process for providing a geometric model database for use in a ubiquitous computing environment to respond to queries about the environment's geometric state, comprising using a computer to perform the following process actions:

accepting information about the geometric state of the environment;

building a geometric model database of the environment based on an initial input of said information, comprising,

establishing a set of entities that are of interest in the environment, each entity of which is represented by at least a coordinate frame unique to that entity and an extent, wherein said extent defines one of (i) the physical size of the entity, or (ii) the service region of the entity,

characterizing the location of each entity in the environment in terms of the coordinate frame of at least one other entity, rather than in terms

of a coordinate frame common to all entities, using a measurement defining the entity's relationship to at least one of said other entities wherein the process action of characterizing the location of each entity in the environment in terms of the coordinate frame of at least one other entity using a measurement defining the entity's relationship to at least one of said other entities, comprises said characterizing comprising an action of detecting errors in the measurements, said error detecting action comprising the actions of:

- (a) inputting a spatial uncertainty estimate associated with the measurement which is indicative of the accuracy of the method used to obtain the measurement;
- (b) identifying cycles of measurements among the measurements, wherein a cycle of measurements is defined as a string of measurements starting at the origin of a first entity frame in the cycle and following measurements from one entity to the next until reaching a last measurement in the cycle representing the relationship between the coordinate frame of a next to last entity of the cycle and the origin of said first entity frame; and
- (c) for each cycle identified,
 - computing the location of said first entity frame's origin as indicated by following the chain of measurements making up the cycle, along with computing an uncertainty region around the computed location of the origin based on a combination of the uncertainty estimates associated with each measurement in the cycle,
 - determining if a given location of said first entity frame's origin is within the computed uncertainty region;
 - whenever the given location falls outside the uncertainty region, declaring that at least one of the measurements in the cycle is incorrect, and
 - whenever it is declared that one of the measurements in the cycle is incorrect, disregarding these measurements and requesting that replacement measurements be provided;

maintaining the geometric model database by modifying it based on the input of updated information about the geometric state of the environment; and

responding to queries concerning the geometric relationships between entities in the environment using the geometric model database.

22. (original) The process of Claim 21, further comprising a process action of repeating process action (c) whenever replacement measurements are provided.

23. (original) The process of Claim 21, further comprising a process action of repeating process action (c) periodically.

24. (currently amended) The process of Claim 4, A computer-implemented process for providing a geometric model database for use in a ubiquitous computing environment to respond to queries about the environment's geometric state, comprising using a computer to perform the following process actions:

accepting information about the geometric state of the environment;

building a geometric model database of the environment based on an initial input of said information, comprising,

establishing a set of entities that are of interest in the environment, each entity of which is represented by at least a coordinate frame unique to that entity and an extent, wherein said extent defines one of (i) the physical size of the entity, or (ii) the service region of the entity,

characterizing the location of each entity in the environment in terms of the coordinate frame of at least one other entity, rather than in terms of a coordinate frame common to all entities, using a measurement defining the entity's relationship to at least one of said other entities wherein the process action of characterizing the location of each entity in the environment in terms of

~~the coordinated coordinate frame of at least one other entity using a measurement defining the entity's relationship to at least one of said other entities, comprises said characterizing comprising an action of revising the measurements, said revising action comprising the actions of:~~

- (a) inputting a spatial uncertainty estimate associated with each measurement which is indicative of the accuracy of the method used to obtain the measurement;
- (b) identifying cycles of measurements among the measurements, wherein a cycle of measurements is defined as a string of measurements starting at the origin of a first entity frame in the cycle and following measurements from one entity to the next until reaching a last measurement in the cycle representing the relationship between the coordinate frame of a next to last entity of the cycle and the origin of said first entity frame;
- (c) for each cycle identified,
 - computing the location of said first entity frame's origin as indicated by following the chain of measurements making up the cycle, along with computing an uncertainty region around the computed location of the origin based on a combination of the uncertainty estimates associated with each measurement in the cycle,
 - determining if a given location of said first entity frame's origin is within the computed uncertainty region,
 - whenever the given location falls outside the uncertainty region, declaring that at least one of the measurements in the cycle is incorrect, and
 - whenever it is declared that one of the measurements in the cycle is incorrect, disregarding these measurements and requesting that replacement measurements be provided, and
- (d) computing revised measurements for those identified cycles in which the given location of the origin is not the same as its computed location but in which the given location falls within the uncertainty region by simultaneously adjusting the measurements based on their associated

uncertainty estimates so as to make the given location of said first entity frame's origin in each of the identified cycles match the location of that origin as indicated by following the chain of measurements making up the cycle;

maintaining the geometric model database by modifying it based on the input of updated information about the geometric state of the environment; and

responding to queries concerning the geometric relationships between entities in the environment using the geometric model database.

25. (original) The process of Claim 24, further comprising a process action of repeating process actions (a) through (d) whenever new measurements are provided.

26. (original) The process of Claim 24, further comprising a process action of repeating process actions (a) through (d) periodically.

27-28. (cancelled)

29. (currently amended) ~~The process of Claim 4, wherein the process action of responding to queries concerning the geometric relationships between entities in the environment, comprises the actions of:~~ A computer-implemented process for providing a geometric model database for use in a ubiquitous computing environment to respond to queries about the environment's geometric state, comprising using a computer to perform the following process actions:

accepting information about the geometric state of the environment;

building a geometric model database of the environment based on an initial input of said information, comprising,

establishing a set of entities that are of interest in the environment, each entity of which is represented by at least a coordinate frame

unique to that entity and an extent, wherein said extent defines one of (i) the physical size of the entity, or (ii) the service region of the entity,

characterizing the location of each entity in the environment in terms of the coordinate frame of at least one other entity, rather than in terms of a coordinate frame common to all entities, using a measurement defining the entity's relationship to at least one of said other entities;

maintaining the geometric model database by modifying it based on the input of updated information about the geometric state of the environment; and

responding to queries concerning the geometric relationships between entities in the environment using the geometric model database, said responding comprising,

waiting for incoming queries from external sources for requests concerning the relative geometric relationship between two entities;₁

whenever a request concerning the relative geometric relationship between two entities is received, determining if a direct measurement exists between the two entities involved in the request;₁

whenever said direct measurement does not exist, employing a breadth-first search to find a measurement path between the two entities involved in the request that has the fewest number of measurement links, wherein a measurement path is a chain of measurements from a first of the two entities involved in the request, through at least one intermediate entity, to the other entity involved in the request;₁

computing the requested measurement information using the measurements in said measurement path, if one was found;₁ and

providing the computed measurement information to the external source making the request.

30. (original) The process of Claim 29, wherein the process action of responding to queries concerning the geometric relationships between entities in the environment, further comprises, whenever as a result of employing the

breadth-first search more than one measurement path is discovered having the same fewest number of measurement links, randomly choosing one of the discovered measurement path for use in computing the requested measurement information.

31. (original) The process of Claim 29, wherein the process action of using a measurement specifying the position and orientation of each other entity's coordinate frame origin in terms of the coordinate frame of the entity under consideration, comprises an action of assigning a spatial uncertainty estimate to the measurement which is indicative of the accuracy of the method used to obtain the measurement, and wherein the process action of responding to queries concerning the geometric relationships between entities in the environment, further comprises, whenever as a result of employing the breadth-first search more than one measurement path is discovered having the same fewest number of measurement links, choosing the discovered measurement path exhibiting a lowest combined uncertainty for use in computing the requested measurement information.

32. (currently amended) ~~The process of Claim 4, wherein the process action of responding to queries concerning the geometric relationships between entities in the environment, comprises the actions of: A computer-implemented process for providing a geometric model database for use in a ubiquitous computing environment to respond to queries about the environment's geometric state, comprising using a computer to perform the following process actions:~~

accepting information about the geometric state of the environment;

building a geometric model database of the environment based on an initial input of said information, comprising,

establishing a set of entities that are of interest in the environment, each entity of which is represented by at least a coordinate frame unique to that entity and an extent, wherein said extent defines one of (i) the

physical size of the entity, or (ii) the service region of the entity,
characterizing the location of each entity in the environment
in terms of the coordinate frame of at least one other entity, rather than in terms
of a coordinate frame common to all entities, using a measurement defining the
entity's relationship to at least one of said other entities;

maintaining the geometric model database by modifying it based
on the input of updated information about the geometric state of the
environment; and

responding to queries concerning the geometric relationships
between entities in the environment using the geometric model database, said
responding comprising,

inputting incoming queries from external sources for
requests to find entities whose extents have a particular geometric relationship to
a prescribed region or extent associated with a specified entity;

ascertaining the relative geometric relationship between the
frame origin of the specified entity and the frame origins of other entities;

transforming the coordinates of the extents associated with
the other entities into the coordinate frame of the specified entity using the
respective relative geometric relationships between the frame origin of the
specified entity and the frame origins of said other entities;

employing a region intersection procedure to determine if
the extents associated with said other entities intersect the prescribed region or
extent associated with the specified entity; and

providing information to the requesting source as to whether
the extents of any of said other entities intersect the prescribed region or extent
of the specified entity, and if so which of the other entities' extents intersect.

33. (currently amended) The process of Claim [[4]] 32, wherein the
prescribed region or extent associated with the specified entity, as well as the
extents associated with said other entities, are characterized by polygonal areas,
or degenerated version thereof constituting a line segment or point, and wherein

the region intersection procedure is a polygon intersection procedure.

34-51. (cancelled)